Excretory System

Most toxic requires large amount of water

Least toxic removed with minimum water.

Animals accumulate

- Ammonia
- Urea
- Uric Acid
- Na^+, K^+, Cl^-, phosphate & sulphate
- CO_2 & water

Major form of nitrog. waste by animals.

either by metabolic activity / excess ingestion

These substance to be removed partially / wholly

Terrestrial adapt. necessitated lesser toxic nitrog. waste for water conv.

Ammonotelic

→ Bony fishes
→ Aquatic amphibians
→ Aquatic insects

Ammonia is

Readily soluble

Excreted by diffusion through body surface or gill surface of fish as NH_4^+.

* Kidneys don't play any major role

Ureotelic

→ Mammals
→ Marine fishes
→ Terrestrial amphibians

by metabolism

Ammonia —(in Liver)→ Urea

Released in blood & filtered out

Some amt of urea

Retained

To maintain desired osmolarity.

Uricotelic

→ Reptiles
→ Birds
→ Land snails
→ insects

• pellet / paste form

minimum loss of water.

JGA → special sensitive region → cellular modifications at the location of contact of

- DCT
- afferent arteriole

Invertebrate → simple tubular forms
Vertebrates → Complex tubular organs. (Kidneys)

Protonephridia / flame cell → Platyhelminth. (flatworm → planaria)
Rotifers
Some annelids,
[Cephalochordates - Amphioxus]
A chordate animal.

mainly osmoreg.
- ionic reg.
- fluid volume reg.

Nephridia (tubular) → Earthworm
Other annelids

- Removes nitrog. waste
- fluid & ionic balance.

Malpighian tubules → Most insects (cockroaches)

- Excretion
- Osmoregulation.

Antennal / Green gland → Crustaceans (Prawns)

excretory funct.

* Nature of nitrog. wastes formed & their excretion vary among animals, mainly depending on the habitat (availability of water)

HUMAN EXCRETORY SYSTEM.

1. A pair of Kidney
2. A pair of uretel
3. Urinary bladder
4. Urethra

- Reddish brown
- Bean shaped
- $T_{12} - L_3$
- Close to dorsal inner wall of abdominal cavity
- 10-12 cm – L
  5-7 cm – W
  2-3 cm – thick
- 120-170 gms.

Each kindney → 1 million nephron.

Kidney → towards centre of inner concave surface → Notch: hilum → BV, ureter, nerves enter.

Calyces ← with projections ← Renal pelvis (Broad funnel shaped space) ← inner to hilum

Outer cortex

Inner medulla → divided into few conical masses → (Medullary pyramids) projecting into calyces

Cortex extends b/w medullary pyramids as renal columns – Columns of Bertini

NEPHRON (tubular)

Glomerulus → tuft of capillaries formed by afferent arteriole – a fine BRANCH of Renal artery & blood carried away be efferent arteriol

Renal tubule.

Malpighian body = Renal capsule + Glomerulus

Renal capsule: Begins with double wall cup like Bowman's capsule enclosing glomerulus.

Renal tubule: Cortex → PCT (highly coiled) → Loop of Henle (Hair pin shaped) → DCT (highly coiled tubular) → Many DCT → collecting duct → Many → Renal pelvis through medullary pyramids in calyces.

Cortical nephron	Juxta medullary nephron.
Loop of Henle short	Loop of henle very long & runs deep in medulla.
Vasa recta Absent/highly reduced	
* More common.	
* Efferent arteriole → Fine capillary network around renal tubule → peritubular capillaries → A minute vessel of this network → Parallel to henle loop → 'U' shaped vasa recta.	

* Amt of filterate formed by kidney / min
→ GFR → 125 mL/min i.e 180 L/day.

* Reabsorption of water also occurs pa. in initial segments of nephron.

FUNCTION OF THE TUBULES

PCT

(lined by simple cuboidal brush border epithelium)

↓

Surface area ↑

↓

Reabsorption ↑

- Water
- Electrolytes (70-80% of)
- Nearly all of the essential nutrients

PCT

- pH balance
- ionic balance

① By selective secretion of H^+, NH_3, K^+

②

② absorption of HCO_3^-

Henle's Loop

* Reabsorption minim. in ascending limb

* Maintains high osmolarity of medullary interstitial fluid.

Descend. limb	Ascending limb
→ impermeable to electrolyte	→ permeable of electrolyte
→ permeable to water	→ impermeable to water.

DCT

* Conditional reabsorption of Na^+ & water takes place here.

- reabsorp. → HCO_3^-
- selective secretion → H^+, K^+, NH_3

maintains

- pH bal.
- sodium - potassium balance in blood

Collecting Duct

→ cortex → medulla.

* Large amt of water reabsorbed here.

* This passage allows small amt of Urea into the medullary interstitium to keep up the osmolarity.

maintains

- pH balance (Selective secret. H^+, K^+ ions)
- ionic balance

Podocyte - epithelial cell of Bowman's capsule. → arranged in intricate manner → minute spaces

- slit pore
- & filtration slits.

Almost all constituent of plasma except protein pass to lumen of bowman's capsule

URINE FORMATION

Glomerular filtration (Ultrafiltration) → Non selective

- Filteration of blood
- 1200 ml by kidneys / min (1/5th of cardiac output)
- Glomerular blood capillary pressure cause filteration of blood through 3 layer
  - endothelium of glomerular BV
  - Basement membrane b/w the two.
  - epithelium of Bowman capsule

Reabsorption

180 L/day (filtrate) → 1.5 L/day (urine)

99% reabsorbed by renal tubules.

* by tubular epithelial cells

- actively → glucose, AA, Na^+
- passive → Nitrogenous waste

Tubular secretion

- H^+, K^+, NH_3 into filterate.

- pH (acid-base) balance
- ionic balance

MECHANISM OF CONCENT. OF THE FILTRATE

→ Mammals ability → Concentrated urine production

↓ play role

Loop of Henle | Vasa Recta

→ Flow of blood through two limbs → loop of henle, vasa recta → Counter current mechanism

→ Proximity b/w Henle loop & vasa recta + Counter current in them

↓

Maintaining an increasing osmolarity towards inner medullary interstitium (In cortex 300 mOsmol^{-1} ↓ 1200 ↓ In inner medulla)

Caused by

Urea

- It enters the thin segment of the ascending limb of loop of henle
- (2)
- transported back to interstitium by collecting tubule.

Nacc

- Returned to the interstitium by the ascending limb of ~~Henle loop~~ vasa recta
- (&)
- Nacc is transported by ascending limb of henle loop which is exchanged by descending limb of vasa recta

→ Presence of such interstitial gradient helps in an easy passage of water from collecting tubule → concent. urine

↓

4 times concentrated than the initial filtrate.

REGUL. OF KIDNEY FUNCTION.

efficiently monitored & regulated by → involving hypothalamus
- hormonal feedback.
- JGA
- Heart (to certain extent)

Osmoreceptors
↓ activated by
① changes in blood volume,
② blood fluid volume
③ Ionic conc.
↓ excessive loss of fluid
↓ receptors activated
↓ stimulate
Hypothalamus
↓
① ADH/Vasopressin → constrictory effects on BV → increase in BP → * GBF ↑ → GFR ↑
② Facilitates ie absorption of water from latter parts.
↓
Prevents diuresis → increase in blood fluid volume

SWITCH OFF

* GBF
↳ Glomerular Blood flow.

JGA
↓
Complex regulatory Role
↓
Fall in GFR
↓
JG cel activate
↓ release
renin
↓
Angiotensinogen (Liver) → Angiotensin-I
↓ By Lungs (ACE)
Angiotensin-II
↓
Activate adr eual corten
↓
Aldosterone
↓
Reabsorption of water & Na+ from DCT.
↓
BP ↑
↓
GFR ↑
↓
Glomerular Blood pressure ↑
↓
Power vasoconstriction

RAAS → Renin Angiotensin Aldosterone system

Blood flow to atria of heart ↑ → ANF release → cause → Vasodilation → BP ↓
↓
Check on RAAS mechanism

* PCT – major site reabsorption & selective secretion.
HL – primarily maintain osmolar gradient within the kidney interstitium.
DCT & collecting duct – extensive reabsorption of water & certain electrolytes, which help in osmoregulation.

DISORDERS OF THE EXCRETORY SYSTEM.

Malfunct. of Kidney
↓
Accumul. of urea in blood → Uremia → harmful, leads to Kidney failure

Can be removed by
↓
Hemodialysis

Blood drained from a convinient artery → Dialysing Unit / Artifical kidney (after adding anticogulant - heparin) ← contains coiled cellophane tube, surrounded by dialysing fluid → have same comp as plasma except nitrog. waste.

Convinient vein ← "Boon" for uremic patients.

Blood cleaned. ← after adding anti-heparin

As nitrog. wastes are absent in dialysing fluid, these subs. freely move out ← Porous cellophane memb. allows the passage of mol. based on conc. gradient.

(Kidney failure)

* Ultimate method in correct. of acute Renal failure → Kidney Transplantation

A functioning kidney from donar → preferably a close relative
To minimise its chance for rejection by immune syst. of host

Transplanted ← Modern clinical proced. have ↑ the success rate of such complic. technique.

RENAL CANALICULI → formed within kidney
- Stone → insoluble mass of crystallised salts (oxalates)

GLOMERULONEPHRITIS → Inflammation of glomeruli of kidney.

* Micturation is carried out by reflex – True
* Protein free fluid is filtered from blood plasma into Bowman's capsule – True
* Henle loop plays imp role in concentrating urine – True
* Glucose is actively reabsorbed in PCT – True

ROLE OF OTHER ORGANS IN EXCRETION

Kidney

Lungs
↓
Large amt of CO_2 (200 mL/min) & sign. quant. of water everyday.

Liver (largest gland in body)
- Bile constituents
  - Bilirubin
  - Biliverdin
- Cholesterol → drugs, vitamins
- degraded steroid hormones.

→ Most of these substances ultimately pass out along with digestive wastes.

Skin

* Saliva – Small amt of nitrog. wastes eliminated through it.

MICTURATION

Urine formed by nephrons
↓
urinary bladder
↓
Stored, till a voluntary signal given by CNS.
↓
initiated by
↓
Stretching of urinary bladder as it gets filled with urine.
↓
Stretch receptor send signal to CNS
→ motor messages
- → contract. of smooth muscle of bladder
- → relaxation of urethral sphincter

→ Urine released.
↓
This neural mechanism
↓
micturition reflex.

Sweat glands
↓
Sweat (watery fluid)
- NaCl
- Small amt of urea
- Lactic acid

* primary function of sweat – cooling effect on body surface

Sebaceous gland
- Sterols
- hydrocarbons
- Waxes

→ through sebum
↓
protective oily covering of skin

On an average,
Urine: 1–1.5 L/day
- → Light yellow
- → watery fluid
- → slightly acidic (pH – 6)
- → charact. odour
- → 25–30 gm urea/day

Metabolic disorders/malfunct. of Kidney
↓
Can be identified by analysis of urine
- → Glycosuria: presence of glucose
- → Ketonuria: presence of ketone bodies

→ Indicative of diabetes mellitus